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THE GOVERNMENT LABORATORY AND INDUSTRIAL RESEARCH[1]

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YOUR Chairman has asked for a contribution to this symposium on Research setting forth the relations of the Government Laboratory to Industrial Research. In the short time available, you will not expect more than the briefest outline of the attitude of one or more typical laboratories toward the encouragement and development of research in industry, the most concise possible of statements describing how a government laboratory functions in relation to industrial research problems, and a bare mention of but a few of them.

There has been a great deal written recently concerning the various aspects of industrial research and especially the rôle that is being played, or should be played, by each of the various types of organization, such as the Engineering Society, the university, the independent research organization, the Government, and industry itself; and the discussion often has centered about the cooperative aspects of research as between two or more of these parties.

It is generally conceded by representatives of industry that industrial research has for its immediate object the increase of profits, and consequently the brunt of the cost of maintenance should be borne by industry, which should also itself carry out at least the greater part of the research work required. There is a very great divergence of appreciation of the need and value of research in the various industries, and the practices and methods also vary greatly.

It is generally conceded that the rôle of the university is to train men and increase our store of knowledge; many think useful cooperative arrangements in research may be made between the university and industry, and many illustrations are available.

It is not the purpose of this paper to go into a philosophical or academic discussion of what part the government laboratory should play on the stage of industrial research but rather, accepting the facts and tendencies as they are, to state briefly, if inadequately, what two of the government bureaus are trying to do to encourage and help industry through research in science, engineering and technology.

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[1] American Society for Steel Treating, September 23, 1921, Annual Convention at Indianapolis.

It has been well said: "All research is in the public interest, and that from the public viewpoint the sole difference between abstract and applied science is one of degree and not of fact; that the important point is increased research activity irrespective of where or by what means it is carried on."

If, therefore, the public has an interest in and derives benefit from industrial, scientific research, it is both fitting and fair for the public, through the agency of the Government Laboratories, to both participate in and help support such research.

It also follows that there should be established and maintained the closest relations between the representatives of industry, on the one hand, and of the government laboratories, on the other. This intimate contact should evidently not be limited to scientific and technical staffs of the industrial and government laboratories, but should embrace also the directors of policy in industry and government.

There is another and most important characteristic of the government laboratory in its relation to this question of industrial research, one that has been often mentioned, namely, the desirability in many cases of having the work done, in whole or in part, by an impartial body representing the public and on whose results will be impressed the stamp of authority; as in cases in which if one or the other party, as producer and consumer, either alone or together, published the results, they would not, however well executed, carry the desired weight.

Again, one should not lose sight of the fact that our government is the largest business organization in the country, the most important buyer and also maintains several types of industrial or manufacturing plant of a highly technical nature. So the government itself, in the conduct of its business, is a party vitally interested in the progress of industrial research, economies in buying, and standardization of products. The results obtained in its laboratories on its own problems are freely given to industry. The rôle of the Bureau of Standards has been preeminent in research for the government and many of its activities in the field of industrial research have been started for the purpose of meeting government needs for information relating to improvements in manufacturing processes, standardization and the formulation of specifications. As illustrations, may be cited the investigations relating to cement, concrete, paper, leather, rubber and textiles, for which small manufacturing plants have been installed.

It is often maintained there are three essential steps in many branches of industrial research, particularly as related to new processes; first, the laboratory investigation; second, the development on a small manufacturing scale; and last, full scale production, all of which require experimentation. The government bureau may be and often is associated with all three of these stages.

What now do we find to be the relation of the government laboratory to the industries of the country?

We may perhaps best approach the subject by asking of what aid can the government laboratory be to the American Society for Steel Treating, to its members individually and to the industries it represents?

There are two government bureaus the work of which is most nearly related to the scope of interests covered by this society, namely, the Bureau of Mines and of Standards. Each of these bureaus is vitally concerned with promoting the welfare of the nation in matters relating to their respective fields. They may be considered as great technical service bureaus to which the engineering, scientific and technical interests of the country may apply for help in solving many of the underlying problems of general interest in mining, technology, engineering, physical and chemical science, and in standardization, on all of which progress in industry is based.

From the viewpoint of cooperation with industry, how do these two institutions function with respect to industrial research, which we may define as research with an avowed utilitarian motive?

Let us consider first the Bureau of Mines. In the annual report of the director for the year ending June 30, 1920, appears this statement:

> During the past few years the bureau has been building up investigative work with outside cooperating agencies in a manner unique among Federal bureaus. The detailed agreements entered into differ among themselves, but the fundamentals are these:
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> 1. Some state, or university, private or semi-private organization has problems in mining or metallurgy the solution of which would benefit itself and the public.
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> 2. These outside agencies agree to pay part or all of the cost, both in personnel and materials, of the investigation, which is to be carried on under the direction of, and according to, the methods of the Bureau of Mines.
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> 3. The Bureau of Mines retains the right to make public and print the results of all such investigations.
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> So successful has this method of solving problems been that at present the bureau has cooperative agreements with State agencies in 11 states, with 12 different universities, and with 19 private and semi-private agencies. And the total amount of money being spent by the outside agencies on these cooperative agreements, mostly under the direction of the bureau, has amounted to approximately half a million dollars during the present fiscal year. In addition, a number of representative concerns in leading mining and metallurgical industries have appropriated money to be spent under the direction of the Bureau of Mines in production of educational motion pictures illustrating various mining and metallurgical industries. The bureau has found that these films are in great demand by the public, and that they have materially assisted the wide dissemination of information concerning the industries.

As in the case of agriculture, the mining industry is scattered over a wide geographical area and the problems to be solved are often local;

therefore it was but natural for the Bureau of Mines to follow the practice of the Department of Agriculture in establishing experiment stations at suitably located points for the study of problems relating to the mining industry.

The Bureau of Mines is also charged with the government work on fuels—a subject of no little interest to the membership of this society—which include, of course, coal and petroleum products of widely diversified types and situated in many areas. In its study of fuel problems, the Bureau of Mines has carried on both the field and station type of investigation but has also been able to concentrate in one or more central laboratories much of its fundamental research work.

In problems relating to process metallurgy, such as the recovering of the various metals from their ores, much the same procedure has, of necessity, been followed as for the mining operations, namely work at outlying stations. In both mining and metallurgical investigations it is the custom to cooperate on an intimate and intensive scale with existing industrial plants, to the very great benefit in the increase of our knowledge and improvement of the processes concerned, to say nothing of the evident economies of such methods of cooperative investigation. With the experience gained by this Bureau in successfully overcoming the difficulties in one region available for new problems as they may arise elsewhere, there is evidently also elimination of much wasted effort in trying out a new or modified metallurgical process.

In its investigations relating to mineral technology and elimination of waste in metallurgical operations, this Bureau is doing much of direct interest to this society, such as smoke and fume abatement, health conditions in shops, furnace design and operation, metallurgical refractories, and the making of alloy steels, a long list, the consideration of which here would take us far afield.

Turning now to the Bureau of Standards, we may note certain differences in methods and procedure as compared with the Bureau of Mines. We have seen how the latter bureau maintains a large number of widely scattered units or stations. In contrast to this decentralized practice, the Bureau of Standards has practically all its work concentrated in a group of laboratories at Washington although it has maintained an important station at Pittsburgh mainly for engineering work on structural materials which station, however, is being moved to Washington; there are also a few small detached stations for cement and chemical testing.

Again, the Bureau of Standards has followed less generally than the Bureau of Mines the practice of entering into formal cooperative agreements with States, and other public or private bodies. We have usually adopted the less formal, but nevertheless effective, practice, in our relations with industry, of orienting and organizing our work through the instrumentality of committees representing industry.

It has been said committees do no work and therefore are unnecessary, but a moment's consideration will show that in many ways a well organized committee is most valuable, if not indispensable, in laying down principles and suggesting policies, resulting from the united experience of all its members. The Bureau of Standards finds in many lines of its work relating to industrial research that the committee method of outlining the problem is the only feasible one. There is established a mutual confidence among all interested parties so essential in attaining the maximum output with minimum risk of misdirected effort.

As a text defining the Bureau's relation to industry, let us quote again from Mr. A. W. Berresford in his presidential address before the American Institute of Electrical Engineers:

> I conceive it to be the prime duty of the industry, first to agree on what shall be the scope of the Bureau; second, to educate the Bureau in its conditions; and third, by demanding that its interests be heeded, to secure adequate support of the Bureau.

At the outset, it may be laid down as axiomatic that the director of the bureau has never considered undertaking any problem in research relating to industry without first consulting representatives of that industry, either as a group through some organized body speaking for the industry or by consulting with men of authority in the industry. Many are the illustrations of this practice; for example, there has been for years a committee appointed by various bodies interested in non-ferrous metals, known as the "Committee Advisory to the Bureau of Standards on Non-Ferrous Metals," or for short, the non-ferrous committee, which meets at the bureau twice a year. All the work on this subject is gone over before and during its execution, so that the non-ferrous metal investigations of the bureau have not only the endorsement of the industry but the industry itself formulates the program. If progress in this domain has been less rapid and extensive than we should like, may we then say that, although the first two of Mr. Berresford's conditions have been met, the third is lacking?

The work on railroad materials has, less formally, been largely mapped out as a result of meetings held at the bureau of representative railroad groups. Sometimes a specific problem that appeals to the bureau may be presented by some railroad together with a manufacturer; such was our work on rails from different ingot types, and the investigation now being conducted on Titanium treated rails; or again a manufacturer's association as that of Chilled Iron Car Wheels may ask the bureau to cooperate in carrying out an investigation—just completed—on thermal stresses in chilled iron car wheels as related to design and braking; or it may be an unorganized group, as that of the steel wheel manufacturers, asking for and getting a similar investigation. Nor should there be forgotten the bureau's activities in the realm of engineering materials in its relation to the numerous committees of the American Society for Testing Materials, which committees are fairly representative of both the consuming and producing elements of their respective industries and represent as well the engineering public. I suppose the list of direct or implied requests for work by this engineering body alone would reach the size of a substantial volume.

Another problem and another type of organization. Whether he realizes it or not, every one in this country is vitally concerned in the limitations set for sulphur and phosphorus content in various grades of steel. If these limits are fixed too rigidly the cost of living rises, if too loosely, the life hazard of all of us is increased. This problem was brought formally to the bureau's attention by two bodies, one representing the government, the other the engineering fraternity; or by the Railroad Administration and the Society for Testing Materials. A joint committee was formed representing the government departments, the specification making bodies, and the manufacturers. The testing and research is carried out in the government laboratories at Watertown, Annapolis and Washington, and the steel is specially produced for the investigation by the manufacturers under the oversight of the committee. A unique feature of the conduct of this investigation is that there is not a two sided table with manufacturers on one side and the users on the other—but it is a round table affair with each man responsible for endorsing each stage of the program so that no member can later say, why did you not do this or that?

The bureau's investigations on electrolysis as related to public service companies and cities are being organized on a somewhat different but nevertheless highly satisfactory basis, in which all interested parties are represented and the program put up to the bureau by them.

Hardly a day passes that there is not one, sometimes several, formal or informal conferences at the bureau by groups representative of industry who are interested in having the bureau undertake problems of research fundamental to their industry, and at those conferences the work to be done is usually mapped out, at least on general lines and often in great detail.

At the present time much attention is being given to problems relating to the elimination of industrial wastes. The possibilites of progress in this field are of unlimited extent. In a sense, of course, all industrial research from which beneficial results are obtained lead inevitably to the equivalent of elimination of waste by conservation and better utilization of materials, improved quality of products, recovery of by-products, increased efficiency of performance, or discovery of new processes and products. There are, however, many instances in industry in which the waste, as such, is evident and manifestly preventable, and it is to problems dealing with these classes of waste to which

I refer. As examples we may mention the enormous losses caused by corrosion, inefficient furnace operations, excessive use of manganese, and other preventable losses of material and energy in steel manufacturing operations.

Another field of industrial research, and one that will grow in importance, relates to our foreign trade, particularly the specification and testing of materials for export. The establishment and maintenance of standards in this wider competitive field will require much more experimental research than might be thought necessary by one who gives the matter but hasty attention. In fact in the realm of standardization and specifications, as those of you know who may be familiar with some phases of this subject, you never get far in writing a specification before you enter the unknown, and the way can be cleared only by further experimental investigation.

We might cite many other types of problem related to industrial research on which the Bureau of Standards is now working or is qualified to assist in solving in collaboration with industry, but I trust what has preceded has given you a better idea than you had before of the relation of the Bureau to industry and the readiness at all times on its part to participate with industry in the solution of those problems of general interest coming within its scope. The same is, of course, equally true of the Bureau of Mines.

Before closing, I would like to mention one other type of activity at the Bureau—still in an undeveloped state—which gives promise of being of considerable value to industry. I refer to the practice started about two years ago of an industry sending men to work at the bureau on problems that industry is interested in having solved and for which the equipment and atmosphere of the bureau may be particularly suited. This practice was instituted by the bureau largely in self-defense at a time when manufacturers were drawing men from it in alarming numbers and it was also coincident with the reduction of the bureau's funds. We call these men Research Associates or Assistants, and at the present time there are twenty, six of whom are working on metallurgical problems, and the others on problems relating to hollow tile, terra cotta, visibility, lime, gypsum, plasticity of fats, cement, and the constants of ammonia. There are great possibilities in the extension of this system under which men are trained as well as problems solved, and the benefits to industry are self-evident.

Much might be said of the educational advantages of the government laboratory in training men for research positions in industry. The Bureaus of Mines and Standards often have been severely crippled by losing men to industry. It is not in general to the advantage of industry to so cripple an organization working for the benefit of industry.

A last word—and only a word—as to the cost of research, industrial or any other. It is trite to say it is expensive, so is life insurance; but it is far more costly not to support research adequately, just as it is not to make provision for future contingencies. It has been said that such government laboratories as the Bureaus of Standards and Mines are luxuries we can easily dispense with; yes, just as the farmer's seed and fertilizer can be dispensed with to his ruin. What does it cost per capita for the Bureau of Standards or the Bureau of Mines? Almost exactly a cent apiece for each inhabitant of this country, which if I were not a member of the staff, I would characterize as dirt cheap, the price of the tax on one ten cent "movie" ticket.

The American Society for Steel Treating is concerned with many problems, some of them of great intricacy, involving not only the perfection of practice in the subject of heat treating but dependent also upon the new facts to be discovered relating to the properties of the various types of steel and the characteristics of many auxiliaries such as fuels, refractories, pyrometers, quenching media, furnace control and design; problems relating to geometry and mass of heating and cooling objects, and many others.

We, at the Standards Bureau, would be glad to see formed within this society, a committee advisory to the Bureau on Heat Treatment of Steel, which would enable us to keep in touch with each other so that the bureau's efforts in this field of investigation would be constantly in harmony with the most progressive minds in the country interested in furthering progress in this subject.

Finally, I want to make a special plea for scientific research in industry at this time. We have been witnessing, during this period of depression, the cutting down and even entire wiping out of many research departments. How many times have we all heard the argument: in times of prosperity we have not the time and do not need research, and in hard times we cannot afford it? In my opinion, the wise Board of Directors is the one which stimulates research in hard times even if it has to borrow money to do so. Competition will be keener than ever as prosperity returns and the company which has in the meantime sharpened its tools by increasing its research facilities will score in the long run. There is no greater economic waste than wrecking a going research group.